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Amputation of the Entire Upper Extremity (including the Scapula and Clavicle), and of the Arm at the Shoulder-joint.

With Especial Reference to Methods of Controlling Hemorrhage. With a Report of One Case of the Former Amputation and Four of the Latter.

BY

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AMPUTATION OF THE ENTIRE UPPER EXTREMITY (INCLUDING THE SCAPULA AND CLAVICLE) AND OF THE ARM AT THE SHOULDER-JOINT.[1]

With Especial Reference to Methods of Controlling Hemorrhage. With a Report of One Case of the Former Amputation and Four of the Latter.

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In this paper I shall consider, first, amputations which allow of simple disarticulation at the shoulder-joint itself; secondly, those cases in which the axilla is invaded, yet to such an extent as to allow of its being thoroughly cleaned out, followed by amputation at the shoulder; and, thirdly, those cases in which the parts are so far invaded as to necessitate the removal of the entire upper limb anatomically, that is to say, including the removal of clavicle and scapula.

I. Simple Amputation at the Shoulder-joint, the Axilla not being Invaded. All surgeons who have performed this operation know that the control of hemorrhage is the key to the situation. I have not had the leisure to make a statistical research into the percentage of recoveries since the introduction of antiseptics, but in a modern amputation at the shoulder-joint the surgeon has a right to expect recovery in the vast majority of cases, provided that the hæmostasis and the asepsis are perfect. The want of accord among surgeons as to the best method of preventing hemorrhage during the operation, and the improvements which have of late been introduced, warrant a reconsideration of the question.

The methods for the prevention of hemorrhage fall into two categories: 1, methods applicable to the subclavian vessels; and, 2, methods applicable to the axillary vessels.

1. *Subclavian methods.* *a.* In most text-books the method advocated is that of compressing the subclavian by the thumb or by a well-wrapped key. "I am of opinion," says Jacobson[2], "that the more the surgeon trusts to this plan solely, the more often will he have cause to regret it. Pressure, however well applied at first with the thumb, aided by a padded key or a weight, is too often rendered uncertain by the neces-

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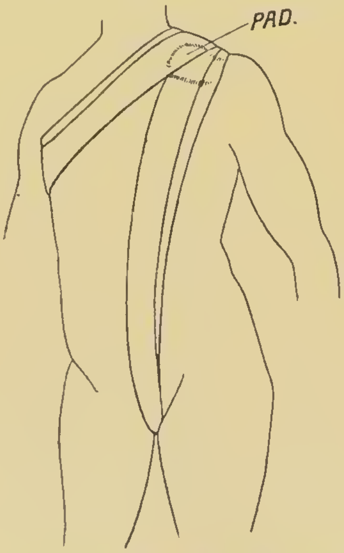
[1] Read before the American Surgical Association, Washington, May 29, 1894.

[2] Operative Surgery, p. 117.

sary changes in position of the limb during the operation, or in the pressure of assistants, a violent gush of blood at the last showing the surgeon that his confidence in the artery being secured is misplaced. Furthermore, an assistant so used is necessarily much in the way of others aiding the surgeon." The opinion thus expressed is precisely my own—formed not as a theoretical conclusion, but after experience and observation, both as an operator and as an assistant who has endeavored, too often unsuccessfully, satisfactorily to compress the artery. In a recent case of Dr. Hearn's, Dr. Allis suggested and practised a modification of this method, which I think of value. The two chief reasons for the want of success of the method are: first, that the assistant gets tired and makes inefficient compression; and, secondly, that his fingers or the key slip from the proper place. Dr. Allis effectually controlled the artery by wrapping the end of a stick about eighteen inches long with some sterilized gauze, and then holding the pad so made in position with his two hands, while compression was made by the weight of his body against the end of the stick, thus overcoming the objection of fatigue, and the retaining of the stick by the fingers was very effective. This method, however, in view of what I shall say later, should, in my opinion, be used only exceptionally.

FIG. 1.



Keen's method of compressing the subclavian by a pad and Esmarch's bandages.

b. In the *Annals of Surgery*, July, 1890, and again in a later communication (*N. Y. Medical Journal*, July 4, 1891, p. 27), I published another method of compressing the subclavian. (Fig. 1.) In this I proposed that a wooden or a pure rubber pad should be placed over the artery and kept in position by an Esmarch bandage, beginning at the pad and passing down the back and under the perineum, then over the pad and around the sound axilla, alternating the two turns, thus both making compression on the artery and holding the pad firmly in place. I have tried this method in the following instance, but found it unsatisfactory and abandoned it in favor of compression of the subclavian, as the patient was a child.

CASE I. *Amputation at the shoulder-joint for extensive burn of the arm; recovery.*—Mary C., of Morrisville, Pa., aged nine years, was sent to the Jefferson College Hospital, on February 20, 1892, by Dr. Groom, of Bristol, Pa. On the 4th of July, 1891, while playing near a fire, her dress caught fire and she was badly burned. The left arm and forearm, excepting a little patch on the inside of the upper arm, were burned from shoulder to wrist. On her left thigh was another large burn and another on the abdomen. After prolonged treatment by Dr. Groom the abdominal wound healed, but the entire arm from shoulder to wrist was one large ulcer, excepting just above the inner condyle; and on the left thigh was another ulcer eight by four inches. For the arm nothing but amputation at the shoulder-joint would answer, not only on account of the size of the ulcer, but because the tissues had been burned entirely to the bone and there was no possibility of recovery of motion.

Operation, March 30, 1892. I attempted first to control the hemorrhage by a supra-clavicular pad of pure rubber gum and an Esmarch bandage, but not being able readily to adjust it, I abandoned its use, and Prof. Brinton compressed the subclavian over the first rib. The granulation tissue resulting from the burn stretched to within two inches of the acromion on the outside and within two and a half inches of the axilla on the inside. On the outside, therefore, I was compelled to utilize one and a half inches of this granulation tissue for the deltoid flap. I used an ordinary bistoury, first cutting a deltoid flap from without inward, and then an axillary flap. The vessels were then tied, and the flaps united with a drainage-tube. During the entire operation the child lost not over four ounces of blood. She reacted well and had no vomiting.

On the day after the operation her temperature rose to 103.6°, and two days later to 104°. By the fourth day, however, it had fallen to the normal and remained practically so afterward. Primary union took place between the flaps, but the deltoid flap and a very small portion of the axillary flap still consisted of granulation tissue on the external surface. On the night of April 27th, her temperature having been perfectly normal, a fire in the neighborhood of the hospital caused great excitement in the wards and sent her temperature up to 105.4°. It fell, however, to 99° by the next day.

On May 12th her brother and herself were both etherized, and I transferred some skin-grafts by Thiersch's method from her brother's thigh to her own, and also to her shoulder. These at first did well, and for three weeks it looked as though the ulcer would be entirely cured, but then the grafts melted away almost entirely. She was discharged on June 14, 1892, with the ulcers in a good condition.

April 3, 1893. The child returned for inspection, and I found that the ulcer on the shoulder-joint was entirely healed, and that on the thigh was reduced to a small ulcer, two by one and a half inches, and was still slowly healing. The skin-grafting seemed to stimulate the wound toward an earlier healing than would otherwise have resulted.

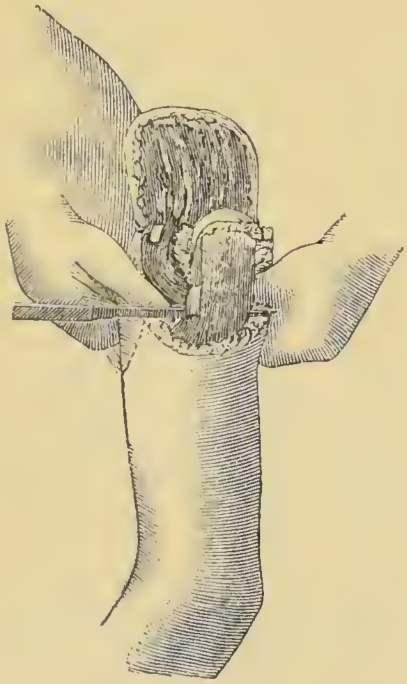
May 1, 1894. She writes me she is in excellent health, the ulcers being healed.

That the method has, however, a place in certain cases in which manipulation *in the axilla itself* is necessary, as in wounds of the axillary vessels, is shown by a case which I quoted[1] in which the late Dr. Charles T. Parkes used it with great advantage. In fact, the operation he did could hardly have been done by any other method. Still, upon the whole, I regard the method as inferior to Wyeth's (*vide infra*).

c. Prior ligation of the subclavian artery. This, of course, is effectual. It has, however, in my mind three objections: First, it adds a second serious operation, and so prolongs the time required for the amputation at the shoulder; secondly, the ligation of the vein is practically impossible without resection of the clavicle; thirdly, if the vein is not ligated there is always the serious danger of the entrance of air during the operation—a danger more than once realized.

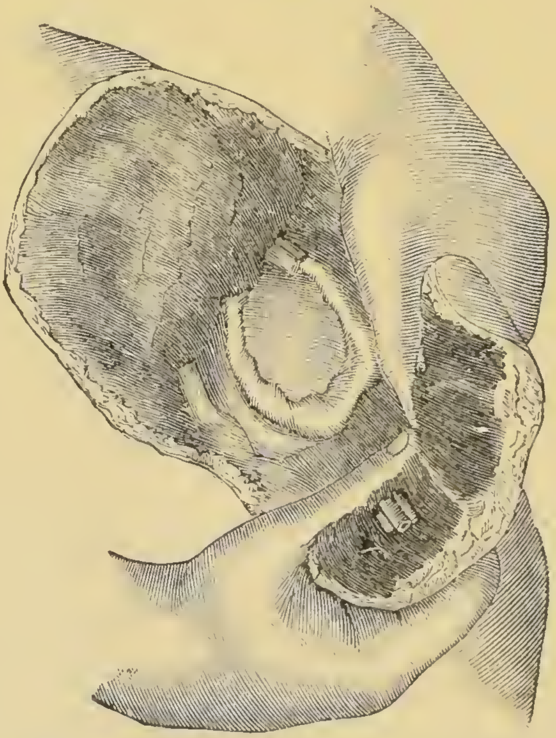
2. *Axillary methods.* These may be divided into two categories: *A.* Methods in use prior to the introduction of Esmarch's tubing, and *B.* Different methods of using Esmarch's rubber tubing.

FIG. 2.



Digital compression of the vessels before cutting the internal or vascular flap. (JACOBSON.)

FIG 3.



Digital compression of the main vessels in the vascular flap after disarticulation. (JACOBSON.)

A. Methods prior to Esmarch's elastic tubing.

a. Compression of the inferior or internal flap by the fingers, which seize the vessels before they are cut. It is too familiar to all surgeons to need a description. Figs. 2 and 3 illustrate it. This is one of the best and most reliable methods, but has the objection that it does not arrest the hemorrhage from all the bloodvessels, but only the main ones, and also that it requires an assistant, who is more or less in the way. It requires a very reliable, cool-headed assistant. Next to Wyeth's pins, however, I think this the best method.

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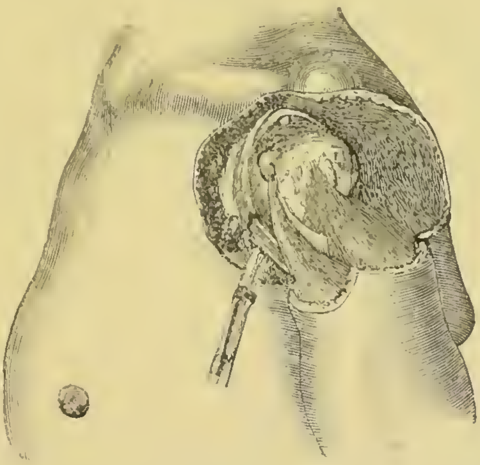
[1] New York Medical Journal, July 4, 1891, p. 27.

b. As an illustration of what simple means may be used in emergencies, the method of Harvey[1] may be quoted. Having no reliable assistants, he simply covered the end of an office ruler with some lint, and had an untrained assistant compress the artery by pushing the ruler well up in the axilla, and made a satisfactory amputation.

FIG. 4.



Seizure of the axillary vessels by hæmostatic forceps before disarticulation. (JACOBSON.)

c. Ligation, or seizure of the axillary vessels with hæmostatic forceps before they are cut. (Fig. 4.) This is also a method which does excellent service and is especially to be commended when one has insufficient or inefficient assistance, or in emergencies, as illustrated by the following case:

CASE II. *Amputation at the shoulder-joint for a mass of ulcerating tubercular axillary and subclavicular glands involving the axillary vessels and nerves; death from exhaustion.*—Miss J. P., aged nineteen years, was kindly sent to me by Dr. W. H. C. Smith, of Millville, N. J., and entered the Jefferson Hospital on November 14, 1891. Both of her grandfathers, two uncles, and one brother died of consumption, and another uncle is very ill with the same disease. About two years and a half ago she noticed a small lump just below the right clavicle, which gradually increased in size. About four weeks ago it broke in the axilla, giving vent to a watery discharge. She has never had very much pain in the tumor, except from tight clothing. Shortly after the tumor appeared her feet began to itch, and from the feet the itching gradually spread over the entire body, so that she is now covered with scratch-marks. When the tumor first appeared she weighed 121 pounds, but her weight gradually fell to 99. She has been gaining of late, and now weighs 108 pounds.

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[1] Indian Med. Gaz., July 1, 1874, p. 190.

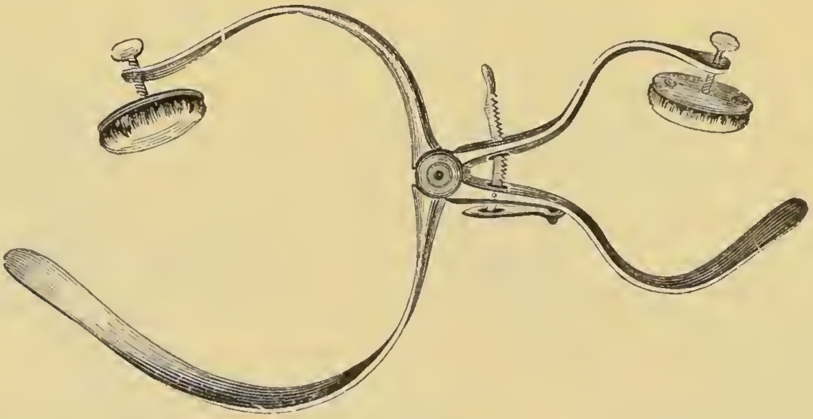
Status præsens. A rather delicate girl, with a mass of glands in the right armpit and under the clavicle, nearly the size of a fist. In the axilla is a large, gaping, deep ulcer, with a very foul smelling discharge. Diagnosis: Tuberculosis of the axillary and subclavian glands. I advised that an attempt should be made to remove the glands, as it was clear that there was no tendency to heal, but, on the contrary, that she was steadily getting worse.

Operation, November 18, 1891. An elliptical incision was made over the axillary mass, including all of the diseased tissue. I dissected upward toward the apex of the axilla and toward the vessels and nerves, in order to determine the relation of the tumor to these structures. I found that the vessels and nerves were so completely imbedded in the tumor that it was evidently impossible to remove the mass without sacrificing all these important structures. Accordingly, I determined at once to do an amputation at the shoulder-joint. I first tied the vessels in the axilla, as they were already exposed, and then amputated by Dupuytren's method.

She made a very good operative recovery, but in the second week the tissues began to break down, with renewed tubercular ulceration. Cough set in, and she rapidly wasted and died on December 7, 1891, nineteen days after the operation, from exhaustion. No post-mortem was obtained.

d. I should mention, perhaps, Gross' compressor. (Fig. 5.) Practically, however, this is never used.

FIG. 5.



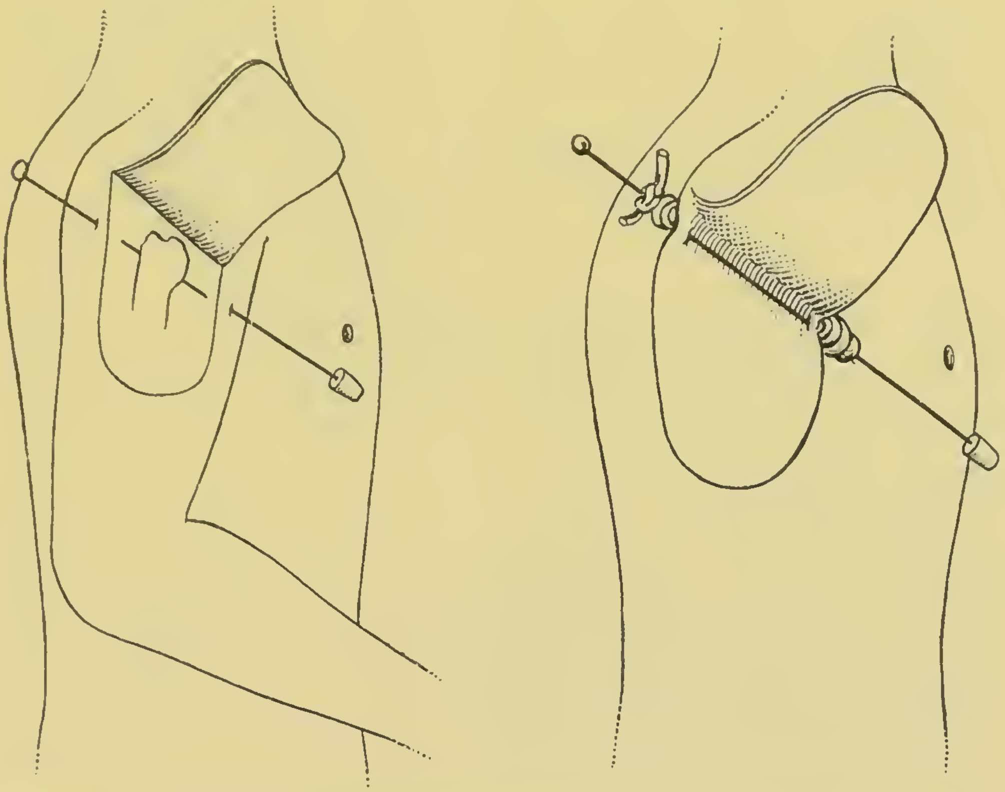
Gross' compressor.

e. Furneaux Jordan's method, by making a circular amputation at the surgical neck of the humerus, securing the vessels as in a hip-joint amputation, the bloodvessels having been compressed by an Esmarch band or other similar method, followed by disarticulation of the upper end of the humerus. The method is not without its advantages, especially in growths or injuries comparatively low down, yet requiring a shoulder-joint amputation, but it is needlessly long and does not seem to me to possess the advantages of the method of my choice, as indicated below.

B. The four following methods are all based on elastic compression of the vessels by means of rubber tubing, and are varieties of the method of hæmostasis introduced by Esmarch.

a. Allis' method. (Figs. 6 and 7.) After making the antero-external flap, a stout pin is passed through the postero-internal flap, between the vessels and the bone, and elastic tubing wound over the ends of the pin either in oval or figure-of-eight. Dr. Allis' frank statement in his report of a case[1] in which he employed this method shows the difficulty which arose. The vessels retracted above the constricting band and produced a serious and embarrassing effusion of blood into the tissues, requiring ligation of the subclavian artery. The danger of aspiration of air into the vein after the tubing is removed and before the axillary vein is secured, should not be forgotten. This method, so far as I know, was first employed by Dr. Allis in 1890.

FIG. 6. FIG. 7.



Allis' method by one pin through the vascular flap and an elastic tubing around the pin.

b. Esmarch's method.[2] (Fig. 8.) In this method an elastic tube is placed in the axilla and drawn tightly over the shoulder, where it is grasped by the hand of an assistant. It is open in my mind to serious objections; first, that the assistant is in the way; second, that he is almost certain to get tired and relax the compression, especially toward the end of the operation, at the very time when the disarticulation is made and the vessels cut; and third, and chiefly, that when the disarticulation is effected, the tubing, not now being held in place by the humerus or by any pin, may easily slip and grasp the flaps, thus obstructing access to the vessels, and in the inevitable confusion of an emergency like this, a large amount of blood may be lost.

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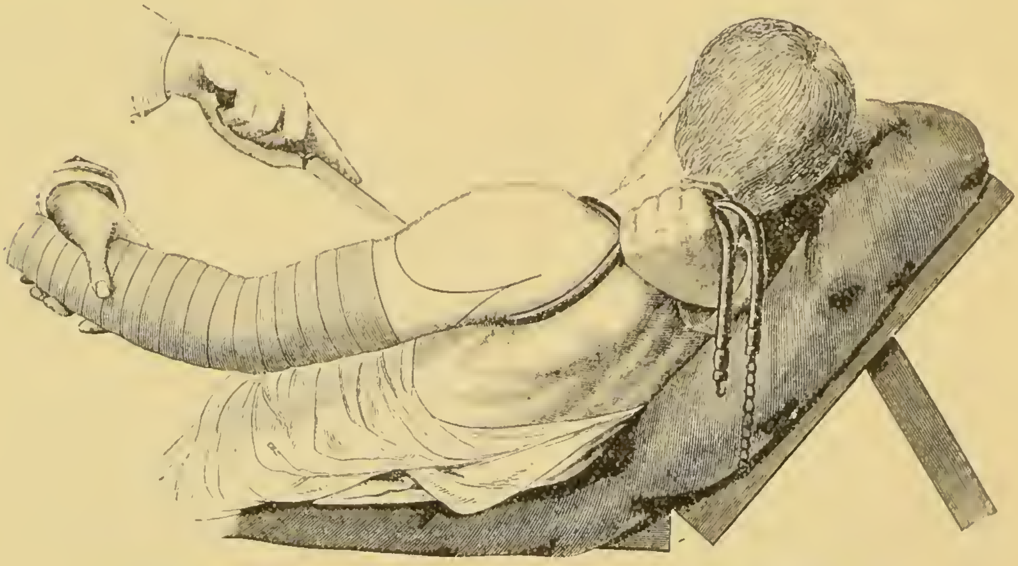
[1] Trans. Amer. Surg. Assoc., 1894.

[2] Kieg's Chir. Technik, vol. ii., p. 193.

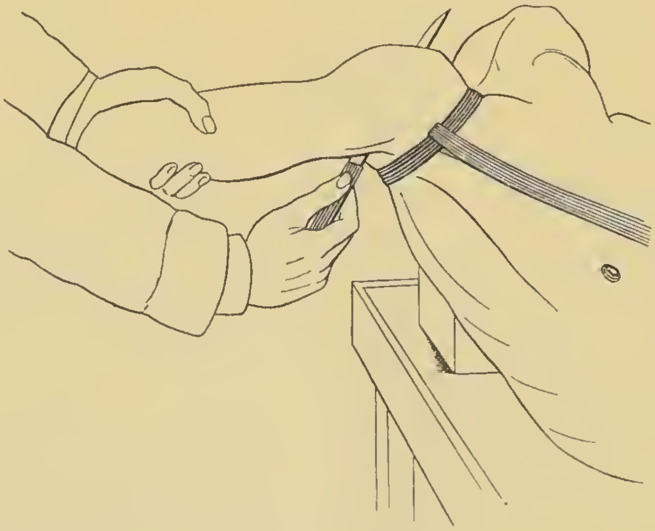
FIG. 8.



Esmarch's method by rubber tubing around the axilla and shoulder.

c. Moore's method. (Fig. 9.) In 1873 Esmarch[1] published his method of controlling hemorrhage by an elastic bandage and tubing. So far as I know, Moore[2] was the first to utilize it in amputation at the shoulder-joint. His brief report of his method is appended:

FIG. 9.



Moore's method by rubber tubing held in place by an anterior bandage.

"In cases of amputation at the shoulder-joint that have come under my observation I have noticed the chief difficulty of the operation to consist in controlling the hemorrhage attending it, necessitating the aid of a quick and competent assistant. I have twice, in performing this operation, adopted a method which renders it almost a bloodless one. I lay a piece of calico bandage across the chest and upper part of the shoulder, and then fix an India-rubber cord or tourniquet around the shoulder over the bandage; this effectually compresses the axillary artery. In order to prevent the India-rubber cord from slipping, an assistant takes both ends of the bandage and holds them across the chest.

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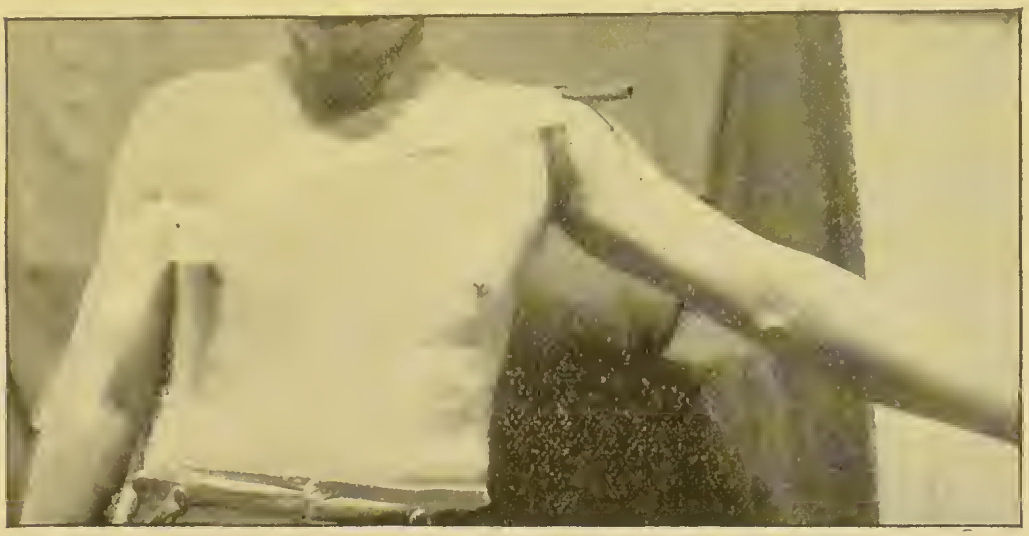
[1] Berlin. klin. Wochenschr., No. 32.

[2] Lancet, 1879, ii. 796.

"If called upon to repeat the operation, I would pass a calico bandage under the India-rubber cord, *behind* as well as in front of the shoulder, then tie the four ends together, and thus dispense with the aid of an assistant."

Fig. 10 shows the latter method of preventing the slipping of the tubing by two bandages tied around the body, as suggested but not figured by Moore. In obtaining the photograph, as the tubing was applied on the living body it was wound rather loosely for obvious reasons. It has the advantage of getting rid of an extra assistant, and doubtless holds the tubing well in place. It obviates the piercing of the soft parts by the pins, but the punctures caused by the pins are of no importance practically. The cut of this method showing the tubing held in place by the anterior bandage alone, in Ashhurst's *Surgery*, is credited to Stephen Smith, but belongs, I think, to Moore. Smith's own cut is not attributed to anyone.

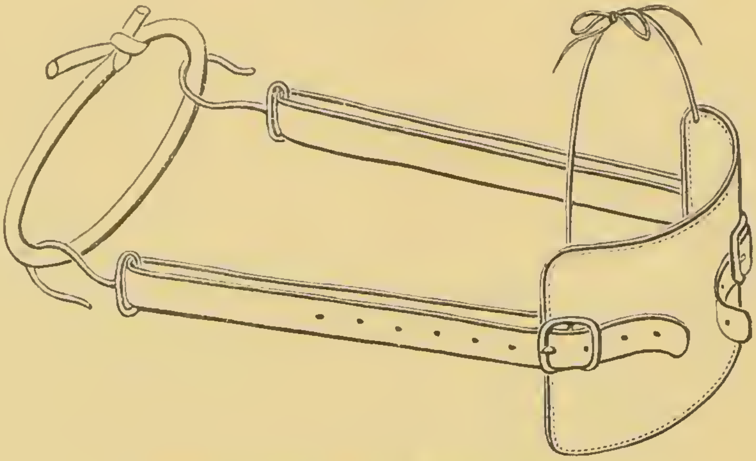
FIG. 10.



Moore's method by rubber tubing held in place by an anterior and a posterior bandage tied under the opposite axilla. (Photographed on the living model by Mr. J. M. Bertolet.)

Dr. G. W. Spencer, one of my assistants, has devised an improved yet simple apparatus for employing this method. It consists of a piece of leather placed under the opposite axilla, and held in place by cords over the shoulder. An anterior and a posterior strap, attached to this axillary leather, hook under the tubing, hold it in place, and can be tightened at will. It is a very efficient means of applying Moore's method. (Fig. 11.)

FIG. 11.



Spencer's apparatus for Moore's method.

d. Wyeth's method by pins and the elastic tubing. Mr. Treves[1] says: "The method of controlling bleeding by means of an elastic band, which is carried across the axilla and brought well up over the point of the shoulder, is strongly to be condemned as useless and dangerous. In such a method the axillary artery is compressed mainly against the humerus. At the moment of the disarticulation the band is apt to slip. It is in the way of the operator, and cannot with any ingenuity be made trustworthy."

Evidently, as he does not refer to them, he means the use of the band as in Esmarch's method, without any pins or bandage, to hold it in place. If so, his criticism is most just. But I am fully convinced that if any surgeon will try the method as outlined below, he will find such satisfaction in its use that he will abandon all other methods in favor of this. I have assisted my colleague Prof. Brinton[2] twice, and I put on record in this paper two other recent cases, with illustrations of the method. The satisfaction and absolute security that I have had in this very serious operation are such that in an amputation at the shoulder-joint I now feel as confident of my ability perfectly to control the hemorrhage as I do in an amputation of the forearm.

This method may properly be called Wyeth's method, as it is essentially an application of his hip-joint method to the shoulder. In fact, it preceded his method of bloodless amputation at the hip-joint, which was suggested by its prior use at the shoulder. In 1888, in removing the outer half of the clavicle, the glenoid, acromion and coracoid processes, and part of the body of the scapula, he first used the pins and rubber tube.[1]

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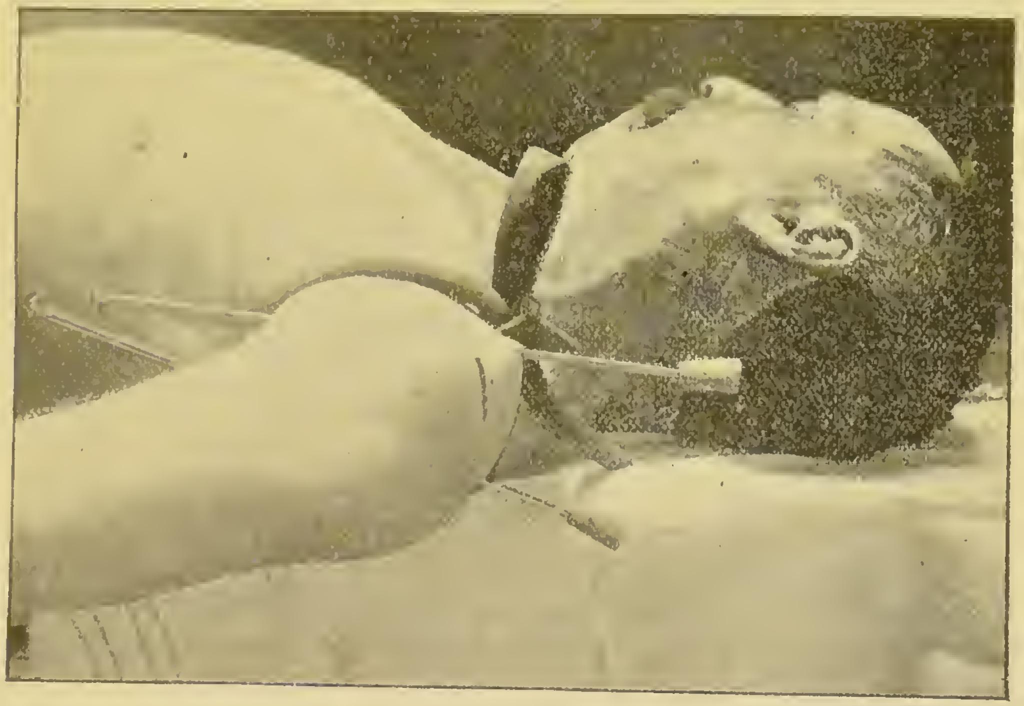
[1] Oper. Surg., vol.i. p. 384.

[2] Annals of Surgery, 1893, xviii. 321.

The operation I have performed as follows: The patient is brought to the edge of the table with the shoulder projecting somewhat beyond the edge. The arm is held at a right angle to the body. Two sharp-pointed cylindrical pins, eleven inches long and one-quarter of an inch in diameter near the head (No. 20, French catheter scale) are used. I have found that a good deal of force is required to push the pins through the tissues, and would suggest that the points be made triangular, like that of a trocar, to facilitate their introduction. The anterior pin is introduced through the middle of the anterior axillary fold (tendon of the pectoralis major) at a point a little nearer to the body than what may be called the centre of the fold transversely. The point of emergence of the pin is of much greater importance than the point of insertion; this should be *an inch within the tip of the acromion.* (Fig. 12.) The pin being pushed through, the point is protected by a sterilized cork. The second pin is now introduced at a corresponding point through the posterior axillary fold (tendon of latissimus dorsi), emerging again an inch within the tip of the acromion. Some little care is needed to avoid striking the spine of the scapula. The exact point of emergence is as I have said, important, in order to avoid the precise objection which Mr.

FIG. 12.



Showing Wyeth's pins and the rubber tubing in place. A piece of black court-plaster indicates the tip of the acromion. (Photographed on the cadaver by Mr. J. M. Bertolet.)

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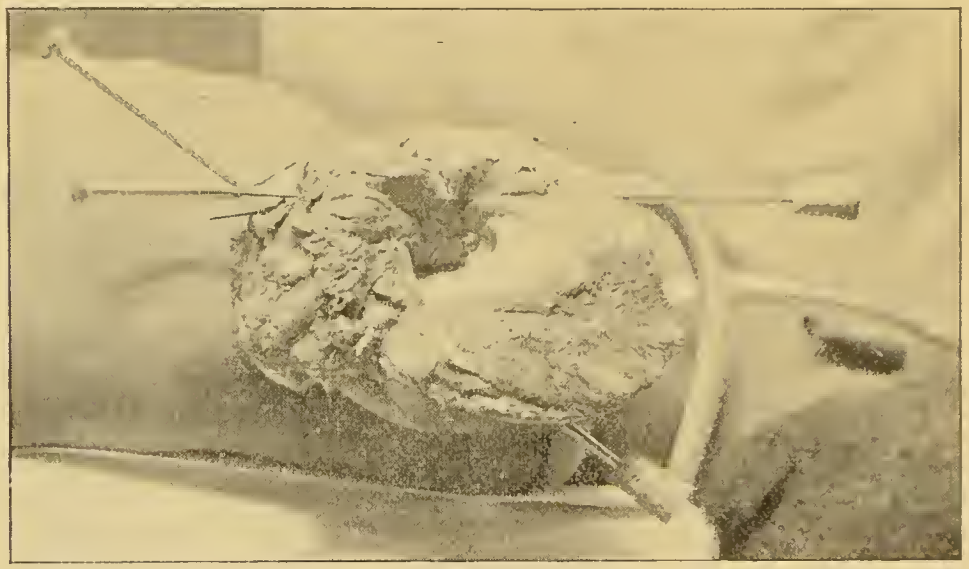
[1] Med. News, Dec. 9, 1893; N. Y. Med. Record, June 24, 1893, and Jan. 13, 1894.

Treves adduces, namely, that if the pin emerges near or at the tip of the acromion, the moment the head of the humerus is removed the tubing is apt to slip downward, compress the two flaps against each other, and thus hide the cavity formerly occupied by the head of the humerus. The vessels may then retract and bleed freely in this cavity, and being entirely inaccessible except by removal of the apparatus, will require ligation of the subclavian, as in Allis' case, or if the tubing is removed copious hemorrhage will follow before the vessels can be caught. This very difficulty arose in the first case in which I assisted Prof. Brinton, but the tubing slipped down to such a moderate extent that we were able to secure the vessels with little difficulty and after only a moderate loss of blood. In the later operations in which I have used it, and have been more careful as to the point of emergence of the pins, no such complication arose. In one of my recent operations, after the arm had been entirely removed, so complete and perfect was the hæmostasis that I stopped for a moment to photograph the perfectly dry flaps before applying any ligatures. Unfortunately the focussing was not accurate enough to use the photograph, but the fact that I was able to wait and take the photograph shows how complete was the arrest of hemorrhage.

FIG. 13.



Showing how complete is the exposure of the inner surface of the flaps and of the glenoid cavity after disarticulation by Wyeth's method. In line with and just below the horizontal pin are two matches in the artery and veins. (Photographed on the cadaver by Mr. J. M. Bertolet.)

The pins being placed in position, a piece of black rubber tubing half an inch in diameter is then wound tightly around the axilla and shoulder on the hither side of the pins. It is important that this tubing should be the pure black rubber, which is very elastic, and not the far less elastic white rubber tubing. The disarticulation having been effected, the main vessels and all visible smaller vessels are tied and the tubing quickly removed. All other spurting vessels are then seized with hæmostatic forceps. I have not troubled myself to remove the pins until after seizing the vessels, so little have they been in my way. The punctures made by the pins heal quickly and are absolutely of no importance.

That the elastic compression of the vessels is by far the most secure method in all amputations is now, I think, unquestioned. In the limbs this can be secured very readily by the ordinary Esmarch methods, but at the hip and the shoulder the difficulty has always been to retain the elastic tubing in place. The only object of the pins is to hold the tubing in place and prevent its slipping. I feel quite confident that anyone who will adopt the method in the manner above indicated will abandon definitively all other methods in favor of this, excepting in emergencies, which, of course, can never be subject to fixed rules.[1]

The following are two cases in which I have recently done the operation with the greatest satisfaction:

CASE III. *Amputation at the shoulder-joint for osteo-sarcoma of the humerus; recovery; recurrence by general sarcomatosis.*—Miss M. G., aged twenty-three years, was first seen in consultation with Dr. Dercum, who had charge of Dr. S. Weir Mitchell's wards at the Orthopedic Hospital and Infirmary for Nervous Diseases. She had been sent there for supposed neuralgia of the arm. About four months before her right arm below the shoulder began to pain her. The pain was so great that she was unable to sleep; this caused considerable loss of flesh. In addition there was marked atrophy of the shoulder muscles. Three weeks before, a small lump appeared on the outer surface of the humerus, barely perceptible to touch. The pain of late has been rather less than it was before, and more intermittent.

Status præsens. June 17, 1893. A slender girl. The right deltoid is markedly wasted and the surgical neck of the humerus somewhat thickened. Vertical measurement from the armpit shows the right side to be three-fourths of an inch and the circumference of the humerus at the surgical neck one and three-quarter inches larger than the other side. Palpation shows a thickening—not now a lump, but a thickening which extended all around the bone as a sort of collar. My diagnosis was an osteosarcoma, and my advice was that an incision should be made in order to verify the diagnosis; and if verified, immediate amputation at the shoulder-joint should be done. This I desired to do at once. Her mother and brother (a physician), however, were so loth to have anything done that I consented reluctantly to wait until five days later.

Operation, June 22d. Since the 17th there has been a distinctly perceptible increase in the thickening around the bone, which confirms me in the diagnosis of a malignant growth. Ether. When lifting her on to the table the nurse accidentally let fall her right arm from a distance of not over four inches, and the humerus was fractured. Wyeth's pins were introduced, the rubber tubing applied, and an incision made down to the bone, which was found to be so soft that the knife easily penetrated it. Larrey's amputation at the shoulder-joint was then done. As little beyond mere skin was taken as possible. The capsular ligament seemed infiltrated and was dissected away with great care close up to the glenoid. The hæmostasis was perfect, not a drop of blood being lost excepting that in the extremity. The vessels were tied and the band taken off. Instantly a large jet of blood showed one vessel which I had not seen, and therefore not secured. It was seized by my thumb and finger before more than an ounce of blood had escaped, and was then secured. A great deal of trouble was caused by the numerous vessels which had to be ligated, requiring the application of thirty-five ligatures. This also was a very threatening feature to my mind, as it showed the vascularity of malignancy. A drainage-tube was inserted and the wound closed.

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[1] *Cf.* Harvey's "ruler" method.

28th (sixth day). Her temperature has never risen above 98.8°. The first night she slept six and one-half hours; last night eight hours; begged for a potato to stay her hunger, and wanted to know when she could sit up out of bed. The stitches were all removed to-day (sixth day), and she was allowed to be out of her bed, the wound having healed by first intention throughout. The drainage-tube was removed at the end of twenty-four hours.

Some cultures were made from the interior of the bone at the seat of the fracture, and Dr. Kyle reported on them as follows:

"From the tubes which had been inoculated, stains showed the presence of numerous bacteria, from which two were isolated, *i. e.*, staphylococcus pyogenes aureus and another which I believe to be streptococcus pyogenes. These destroyed what other germs were present, for by the second inoculation these two alone remained; no cells were found. The pathologist's report as to the nature of tissue and bone, of course, will determine whether it be malignant, but from a bacteriological standpoint I would say it was osteo-myelitis."

Dr. Charles W. Burr reported as follows on the specimen:

"The arm of Miss B. gives evidence of sarcoma. As you know, Dr. Kyle found the micro-organisms of pus in some fluid from the humerus. I think the explanation is as follows: First, an osteo-sarcoma; secondly, in it a focus of secondary inflammation."

May 10, 1894. In the summer of 1893 the growth returned at both ends of the right clavicle. In the autumn a faithful and persistent trial of the effects of inoculations of the products of erysipelas and the streptococcus prodigiosus furnished by Dr. W. B. Coley, of New York, was made, but though reactions were obtained after some of the inoculations, no perceptible effect on the growth was perceived. During the winter of 1893–94 growths appeared at four points on the head and probably internally. It seems likely that her life will be terminated within the next month.

Case IV. *Amputation at the shoulder-joint for traumatic neuritis; recovery.*—My object being to record rather the surgical than the neurological aspects, I shall report this case very briefly, reserving the fuller details for another occasion.

Mrs. J., aged forty-three years, was admitted to the Orthopedic Hospital and Infirmary for Nervous Diseases, under the care of Dr. Morris J. Lewis, September 5, 1892. Twenty-two years ago she struck the back of her right hand on a grate between the first and second metacarpal bones. The hand swelled immediately and was very painful. Six months afterward two inches of a nerve are said to have been removed from the back of the hand, but immediately after the operation there was no numbness to touch. The pain became more severe, and gradually a universal neuritis of the entire arm, most marked in the ulnar nerve, set in.

I first saw her in January, 1893. Everything had been done therapeutically, and on January 16th, at the request of Dr. Lewis, I stretched the brachial plexus in the neck. On February 4th, no permanent good having come from the stretching of the brachial plexus, I stretched the ulnar nerve in the axilla, and later, on May 27th, I excised three and one-eighth inches of the ulnar nerve.

Her arm having become absolutely useless, and also a great burden, as she had to carry it around all the time, she begged for the relief which amputation would afford. Accordingly, the pain being still no better, on April 12th, 1894, I amputated the arm at the shoulder-joint by Wyeth's method, with pins and elastic rubber tubing. The flaps were so completely thrown back and bloodless after the disarticulation, that I had ample time to take a photograph of the flaps in order to show how entirely the glenoid cavity and the inner surface of the flaps were exposed and accessible. The stump was so vascular that, although the patient was a slender woman, and with a shrunken arm, forty-eight ligatures were required before the hæmostasis was satisfactory. On the fifth day half the stitches were taken out, and on the ninth day all of them were removed. A drainage-tube was used for forty-eight hours. A slight later infection took place at both ends of the drainage wound, which delayed the definitive healing, but all the rest of the wound was well in nine days after the operation.

May 10*th*. She made a speedy recovery and is much better, although not entirely cured of her neuralgic pains. In fact, from the start I advocated division of the posterior nerve-roots within the spinal dura, but she has never been willing to have this operation done, and hence the various attempts at relieving her by the operations already mentioned.

II. Amputation at the Shoulder-joint in Cases in which the Axilla is Invaded so High that Wyeth's Pins cannot be Used. In 1812 Delpech[1] proposed to make "an oblique incision extending from the external third of the clavicle to an inch above the inferior border of the great pectoral muscle. We thus discover and can cut, near to its origin on the coracoid process of the scapula, the lesser pectoral. The index finger is then carried through the cellular tissue along the serratus magnus muscle, then the subscapular . . . and is used as a hook in order to draw outward the mass of vessels and nerves. The artery is always situated at the anterior part of the mass, is surrounded and, as it were, indicated by the two roots of the median nerve, and nothing is easier than to surround it with a ligature which will embrace nothing else. This process appears to me preferable in that it produces but little injury to the parts, that it leaves a certain space between the ligature and the trunk, and permits temporary compression of the subclavian artery above the clavicle on the first rib." He states that he has only done this operation, however, on the cadaver. Fig. 14 on the cadaver illustrates the site of the incision. With modern antiseptic methods and modern retractors and the electric forehead-light, or even without the latter, this procedure can be employed with much greater advantage than formerly. In addition to this if it is necessary to secure more room modern methods permit us to divide the fibres of the muscles on either side of the incision parallel to the clavicle, and to restore their continuity by suture. The advantages of this procedure are:

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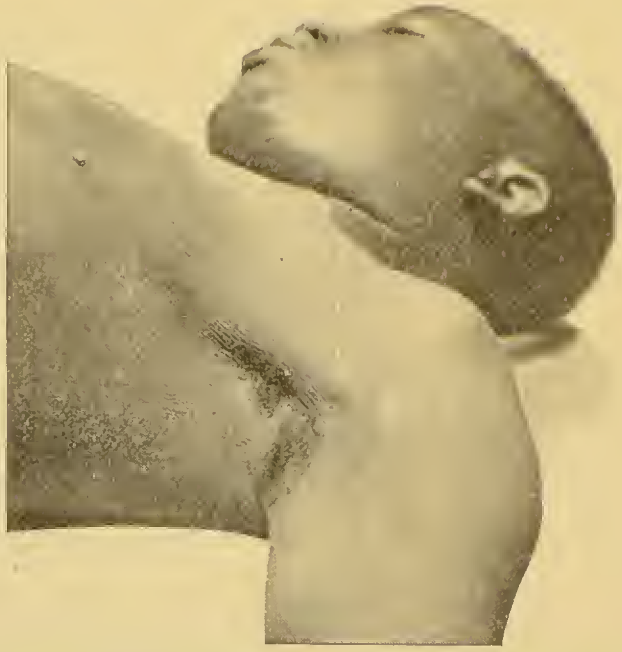
[1] Dict. des Sci. Méd., tome i. p. 289.

FIG. 14.



Showing the line of the incision between the deltoid and great pectoral muscles. (Photographed on the cadaver by Mr. J. M. Bertolet.)

1. That it gives us wide access to the axilla, especially to its apex, where the vessels lie.

2. We can determine with ease how far and how great is the invasion of the axilla. If the invasion is so extensive as to make an operation hopeless, we can abandon the operation and the patient recovers within a very brief time.

3. If, on the other hand, it is decided to proceed with the operation, the incision already made not only admits of the ligature of the vessels but also serves as the inner part of the deltoid incision. The vein, of course, should be tied as well as the artery.

I have employed this method once in a case of amputation at the shoulder joint in which a sarcoma of great size had invaded the axilla nearly to the clavicle. Six months have elapsed since then, and the patient is entirely well. (See Case IV. below.) The ease with which the operation was done and the paucity of hemorrhage during its performance have commended it to me very seriously. In another case in which I recommended it to the attending surgeon, he deemed it best not to adopt the procedure, but to proceed by the ordinary method, the vessels in the inner flap being compressed by the thumbs of an assistant. A large amount of blood was lost during the amputation at the shoulder, and when the axillary mass was removed, as the second step of the operation, the same vessels were cut again at a higher point, and such severe hemorrhage followed that the patient died shortly afterward. In a third case in the practice of my colleague in the Jefferson Hospital, Dr. Hearn, the incision was made and the dissection was then carried out sufficiently extensively to decide that complete removal of the axillary mass was impossible; the operation was therefore abandoned and the wound was well in a very few days.

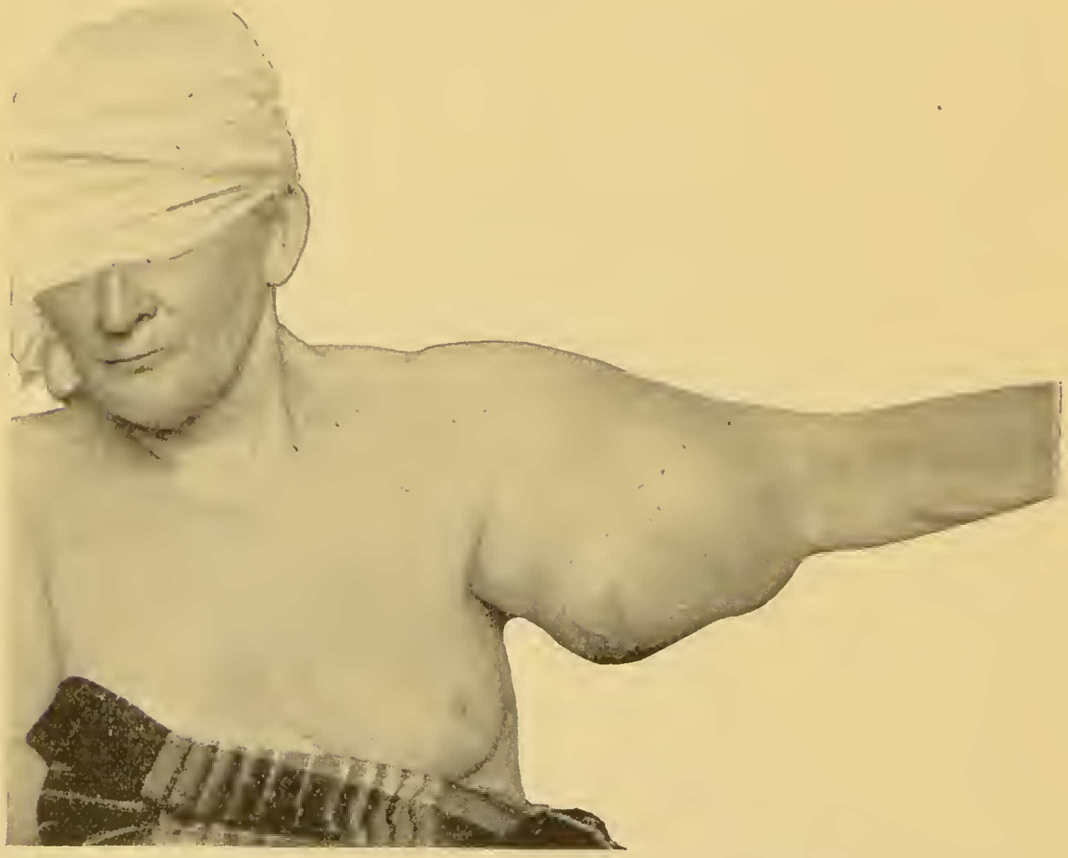
The following case illustrates the method, and is peculiar in the cause and duration of the disease:

Case IV. *Amputation at the shoulder joint for a large sarcoma of the arm and involving the axilla; recovery.*—Miss S. J. G., aged fifty-six years, Christiana, Lancaster County, Pa.; was first seen at the Jefferson College with her nephew, a student in the Jefferson Medical College, November 7, 1893. Her family history is negative. She is a dressmaker by trade, and has never been ill before. Ceased menstruating six years ago.

Forty years ago, when she was about fifteen or sixteen years of age, she cut herself in the palm of her left hand. A short time after this she observed a lump the size of a grain of corn in the left armpit. This remained stationary for a year or so, and then began to grow, finally reaching the size of a hen's egg. The tumor remained permanently of about this size until September, 1892. It then began to grow rapidly. She consulted a local physician, who advised her to let it alone. Its present dimensions are as follows: circumference, twenty-three inches; vertical diameter, ten inches, from the level of the acromion downward. (Fig. 15.) It extends into the axilla so far that it would be impossible to place Wyeth's pins and the circular elastic tubing sufficiently high to remove all the diseased tissues. Apparently there are no separate glands involved. The tumor is hard and soft in different places, at points almost fluctuating. It is freely movable. The pain has been very slight. Her general health is good. Urine normal; specific gravity 1022; no albumin or sugar. Diagnosis sarcoma.

Operation, Jefferson Medical College Hospital, November 9, 1893. An incision was made from the clavicle nearly to the axilla in the interval between the deltoid and the great pectoral. The muscles were separated from each other, and in order to give more room, some of the fibres of the pectoral were divided. In a few moments I entered the apex of the axilla. I found that the growth had extended well up toward but not to the clavicle, and I was able to ligate the artery just as it changes from subclavian to axillary. The artery lay directly behind the vein in the supine position, and so deep that it could only be reached by ligating, dividing, and turning aside the vein. The incision already made was then utilized in making the deltoid flap. This was dissected away from the bone, and disarticulation was effected with very little hemorrhage. The vessels which spurted in the deltoid flap and some on the pectoral side were quickly caught with hæmostatic forceps. The glands in the axilla were thoroughly cleaned out. The flaps were then united with silkworm-gut, and two drainage-tubes placed in the wound.

Fig. 15.



Sarcoma of the arm and invading the axilla. (Photographed by Dr. C. A. Weaver.)

The ease with which the operation was done and the small amount of hemorrhage were most satisfactory. Probably, excepting from the arm, not over four ounces of blood were lost in all. The arm and the blood from it were given to Prof. Coplin for examination.

The drainage-tubes were both removed on the third day. I retained them as long as this because of the very considerable oozing which took place. On the seventh day I removed five of the stitches, and on the sixth day reintroduced the drainage-tubes, for the reason that on the fifth day, although the temperature only rose as high as 101°, infection took place, followed by profuse suppuration. There was considerable odor, and small masses of necrotic tissue came away. Toward the end of the third week I reopened the central part of the wound in part, so as to give freer exit to the pus. The two ends where the drainage-tubes had been soon closed, and the discharge escaped entirely at the middle.

She left the hospital on December 16th, her temperature having been practically normal for nearly two weeks, with a good, granulating wound, all healed excepting at the centre.

Dr. Coplin reports that the growth is a mixed-cell sarcoma, and that there were peptones found in the blood, with a moderate increase in the number of leucocytes.

May 10, 1894. The patient is in good health.

III. Control of Hemorrhage in Cases in which it is Necessary to Remove the Arm, the Scapula, and the Clavicle—the Interscapulo-thoracic Amputation of the French. This formidable operation was first done by Ralph Cumming, a surgeon in the English navy, in 1808, on account of a gunshot injury; in 1830, by Gaetani Bey for an injury by an explosion. The next four operations, all for disease, were all done in the United States: by Dixie Crosby, of New Hampshire, in 1836, for carcinoma; by Twitchell, also of New Hampshire, in 1838, for malignant disease; by George McClellan, in the same year and for the same cause; and by Mussey, in 1845, for a sarcoma. All these first six cases recovered. Since that time the operation has been done with increasing frequency, as our methods have improved and as we have recognized the fact that such an extensive amputation gave a much better promise of permanent cure, especially in sarcoma of the upper end of the humerus.

In the sixth edition of Ashhurst's *Surgery*, 1893, p. 135, are recorded 17 cases in which the upper extremity had been torn off by accidental violence and which terminated favorably, and 89 cases in which these parts have been removed by operation, with 67 recoveries and 22 deaths. To these should be added 14 cases done by v. Bergmann,[1] which all recovered with the exception of one—an extraordinarily favorable showing. Von Bergmann's fatal case was a very remarkable one. He found that the sarcoma had extended through the subclavian vein to the superior vena cava, and to prevent a fatal hemorrhage he resected the sternum and tied the superior cava. The patient died very promptly. Probably there are other cases, but I have not searched for them, as it is not intended in this paper to consider results so much as the methods of dealing with hemorrhage.

The key of the situation here is, of course, as Berger in his capital monograph, *l'Amputation du Membre Supérieur*, 1887, has insisted, is the perfect security of the hæmostasis. The details of the procedure for arresting hemorrhage have varied somewhat with different authors as follows: 1. Simple compression of the subclavian artery. 2. The artery has been compressed after resection of the clavicle. 3. The subclavian has been ligated prior to beginning the amputation proper. 4. The middle half of the clavicle has been resected and the artery tied. 5. Wyeth[2] first tied the artery, then formed his flaps, and when the arm, clavicle, and scapula were only connected with the trunk by the vein and nerves, secured the vein and cut the nerves. This seems to me a very dangerous procedure, as the weight of the arm might easily tear the vein and allow the entrance of air. 6. The artery and vein have both been tied after resection of the middle portion of the clavicle. This seems to be by far the preferable method; its advantages being thus enumerated by Berger:

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[1] Nasse: Sammlung klin. Vorträge, Neue Folge, No. 86.

[2] New York Medical Journal, January 17, 1891, p. 57.

It absolutely prevents the hemorrhage resulting from division of the axillary artery and its branches.

It diminishes the amount of blood lost during the operation.

It absolutely prevents the entrance of air into the vein, which has been the cause of several deaths.

It permits of a large opening of the space between the upper extremity and the chest by section of the greater and lesser pectoral, and with almost no loss of blood.

And finally it enables us to divide the posterior attachments of the upper extremity (where the arterial circulation is still going on) at the end of the operation.

The preliminary resection of the clavicle and ligation of the vessels is by no means even itself easy, especially in cases in which the disease has invaded the clavicular region, or in which the arm has been torn off and the vessels have retracted. Thus, in a pathological case, Macnamara was unable to find the artery, and in a traumatic case Parise was equally baffled in his endeavors to find the vein. (Berger.)

The steps of the operation may be described as follows:

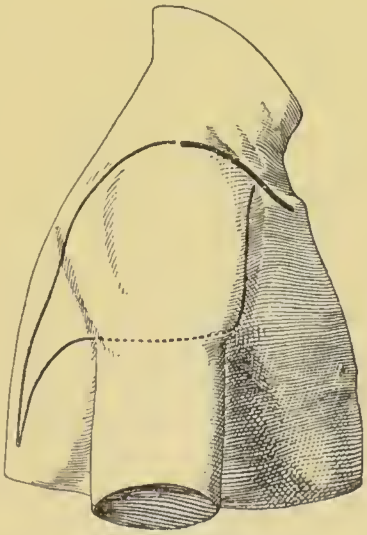
1. The resection of the clavicle. An incision is made on the line of the bone and directly down to it. The soft parts, including the periosteum if it can easily be done, are well separated from the bone largely by a blunt dissection. A retractor or periosteal scraper being introduced under the clavicle, the middle half of the bone is resected obliquely from above downward and outward. It is not necessary, nor even is it best to resect the inner end of the clavicle. In 1837 Mussey did this, with the result that air obtained entrance to the vein—in spite of which, however, his patient recovered.

2. Ligature of the artery and vein. As pointed out by Berger and Farabœuf, it is best to search for the artery just at the point where it becomes the axillary by an incision of the periosteum of the clavicle, if this has been left, and of the subclavius muscle. "In applying the ligature at this level we find a noteworthy landmark in the presence of that branch of the brachial plexus which goes to the great pectoral. This branch is easily seen and still more easily felt with the finger. It passes obliquely in front of the artery, leaves the vein on its inside, and we can easily guide ourselves by the visible and tangible relief made by this nerve, and find at will either the artery or the vein without having recourse to the tubercle of the first rib." (Berger.) In my own

case (*vide infra*) this nerve was not seen. It is best, as a rule, first to tie the artery with two ligatures and divide the vessel between them, and then to tie and divide the vein. If this order be followed, the vein is lessened in diameter, its ligation is less difficult, and if it be torn, as happened to me in the case related below, the wound is not flooded with blood, and the vessel can be much more readily secured. If the vein be greatly distended so as to obscure the artery, it may occasionally be best to tie it first with two ligatures and divide it in order to obtain access to the artery.

Should the vein be accidentally punctured or torn, the great danger, of course, is the entrance of air. Instantly the surgeon should cover the aperture with his finger and temporarily secure the vessel by means of hæmostatic forceps. He can then isolate, ligate, and divide it. The vessels being secured, the flaps are then formed. It is best, as a rule, first to make the anterior incision, as that gives us access to the axilla. Division of the greater and lesser pectoral muscles and of the brachial plexus then allows the arm to fall away from the trunk, thus exposing widely the space between the scapula and the chest. Next, the posterior flap is fashioned, the soft parts being rapidly dissected away over the scapula, and the muscular attachments to that bone divided. The bleeding vessels are readily seized by hæmostatic forceps.

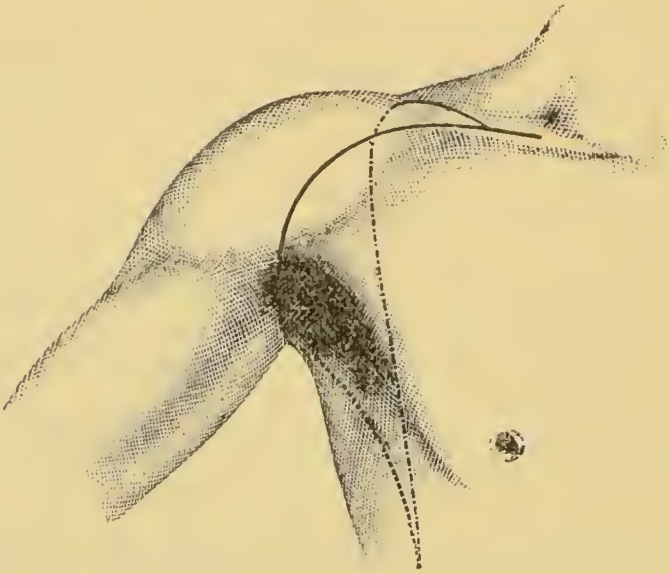
FIG. 16.



Incisions for the two flaps in amputation of the entire upper extremity. (BERGER.)

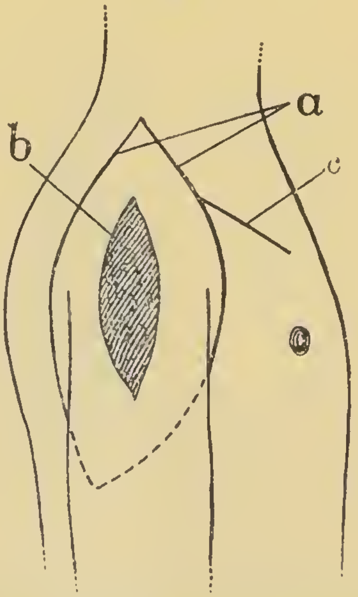
The exact mode of making the flaps varies, and must be determined in each case by the character and extent of the disease. The typical posterior incision of Berger (Fig. 16) prolongs that over the clavicle for its resection and the ligature of the subclavian down to the inferior angle of the scapula. The anterior goes vertically downward between the arm and the chest, opening the axilla, and then meets the other at the inferior angle of the scapula. (Fig. 16.) Somewhat different incisions are given by Treves (Fig. 17), the dotted portions being on the back of the body. In my own case, as the soft parts above the acromion were invaded, I made a much simpler incision, an oval beginning three inches above the acromion, and passing one in front and the other behind the shoulder, and meeting in front of the inferior angle of the scapula. (See Fig. 18.) The flaps, if too large, should then be trimmed so that they will adjust themselves snugly to the sides of the thorax. This trimming may be rather frequently necessary, for it is difficult to judge beforehand exactly what should be the size and shape of the flaps.

FIG. 17.



Incisions for the two flaps in amputation of the entire upper extremity. (TREVES.)

FIG. 18.



a. Incisions for the two flaps in my own case of amputation of the entire upper extremity. *b.* The area of disease. *c.* The incision for resecting the clavicle and securing the subclavian vessels. (KEEN.)

Fortunately, the removal of the clavicle, scapula, and arm leaves so small a stump (if one can apply this term to the rounded border of the chest) that a much smaller amount of muscular and cutaneous flap is required than would at first be thought probable.

As a rule, recovery follows in from two to three weeks. In my own case the stitches were removed on the fifth and seventh days, and the patient was out of bed eight days after the operation. The probabilities are very favorable in my case for permanent cure. Prof. Coplin reported that the case was one of giant-cell sarcoma, and as it had grown very slowly during the four years in which it had existed the probabilities are that the patient will escape any recurrence. In most cases, however, in which the bone is involved, recurrence of the disease has been the rule, but with our later experience it seems to me we ought to get in the future much better results. Observe, first, the low rate of mortality in the more recent operations—one in fourteen of v. Bergmann's. Note, secondly, that we can often amputate wide of the disease in consequence of the relative smallness of the flaps required to cover the chest-wall. Moreover, Thiersch's method of skin-grafting enables us to cover in immediately any moderate defect in the size of the flaps. In view of these facts I would urge, with Berger, that in all cases of malignant disease of the upper end of the humerus, or even of the lower end when it is already diffused, we should not content ourselves with mere amputation at the shoulder-joint, but should at the same time extirpate the scapula and clavicle. This is exactly in line with our modern methods of operation on the breast, in which the armpit is thoroughly cleaned out and a layer of the pectoral muscle removed in order to secure immunity. The very happy and marked increase in the percentage of cures in cancer of the breast should lead us to early and radical operation in cases of malignant disease of the humerus, and still more in similar disease of the soft parts of the arm.

The extraordinary fatality of osteo-sarcomata of the humerus and femur are well known. No one, so far as I am aware, has made a careful statistical investigation of the final results for the humerus, but Borck[1] has found that in eighty-seven cases of amputation at the hip joint for osteo-sarcoma of the femur, *not a single case* can be proved to have been permanently cured. A similar review for the arm would, I fear, show little if any difference from this doleful report. The result in sarcoma of the soft parts is much better. One reason for the frightful ultimate fatality of osteo-sarcoma which seems to be plausible, and which I believe has not heretofore been suggested, may be found in the physiological fact that the bone-marrow has a share, and probably an important one, in the production of the red blood-cells. If this be so it is possible that by this means the blood may be contaminated at its very fountain, and the disease being thus distributed, metastasis is readily produced, even if the disease has been so thoroughly removed that recurrence *in situ* does not take place.

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[1] Arch. klin. Chir., xl. 941.

CASE V. *Amputation of the arm, clavicle, and scapula for sarcoma of the shoulder; recovery.*—Miss K. M., aged twenty years, of Gettysburg, Pa., was kindly sent to me at the Jefferson College Hospital by Dr. E. W. Meisenhelder, of York, Pa., November 17, 1893. The family history is negative as to both growth and tuberculosis. She has always been in good health until four years ago, when she experienced a constant, dull, aching pain from the right elbow to the right shoulder. The only assignable cause for this was a fall a year earlier, in which she sustained a severe sprain of her right wrist. About a year after the pain appeared the shoulder began to swell slightly, attended with increased pain. The first appearance of the growth was at the insertion of the right deltoid muscle. From this it has gradually extended upward, until it now involves the outer end of the clavicle and the acromion and a part of the axillary border of the scapula. I have spoken of it as a growth, but really it was rather an induration and infiltration of the tissues, with but very little increase in size. It resembles not a little an atrophic scirrhus of the breast. The growth is very hard, almost as much so as cartilage, slightly granular on the surface, entirely immovable, and evidently attached to the bone. The shoulder-joint is also absolutely ankylosed. The pain is constant and severe. At times she has lost in weight, but is now gaining somewhat. Her general health is good. The urine is negative.

Operation, November 20, 1893. The scapula, as well as the humerus, was evidently involved, but how far the scapula was involved beyond its head was uncertain. The acromial end of the clavicle was probably involved, and the soft parts just above the shoulder, extending a little way into the neck, were dense and hard. It was necessary, therefore, to remove the entire upper extremity, including the clavicle and scapula. Berger's typical incisions, starting from the clavicle to form anterior and posterior flaps, would leave on top of the shoulder some of the diseased tissue. The only way in which the disease could be entirely removed, was by an oval incision beginning on the neck and ending near the lower angle of the scapula.

The arm was first bandaged with Esmarch's rubber bandage up to the deltoid insertion, in order to save her all the blood that was possible.

I then made an incision horizontally in the line of the clavicle, exposed the bone, and resected somewhat more than the middle third. I next proceeded to ligate the vessels, the artery first, in order that the arm should not be filled with blood, nor the vein so large and tense as it would be were it tied first, and thus prove an obstacle in reaching the artery. I found the task of ligating the vessels an extremely difficult one. The space between the scalenus anticus and the brachial plexus was no wider than the artery itself, and access to it was blocked by a large vein, presumably the suprascapular. Finally, however, I secured the artery with two silk ligatures, and divided it. Securing the vein was still more difficult, as it was adherent to the fascia in front. In endeavoring to reach it, a large vein under the inner sawn end of the clavicle tore, and gave me much trouble, but finally, partly by a ligature around the tissues, in which lay the vein, and partly by a ligature which was applied temporarily around the tissues and around the sawn end of the clavicle, in a groove sawed in the bone so as to prevent the slipping of the ligature, I was able to control it. In addition to this, in trying to separate the subclavian vein from the fascia, a small hole was torn in the vein. I appreciated now especially the wisdom of tying the artery first, for had the same tear occurred before the artery was ligated the wound would have been flooded with blood, with all the embarassments which would have attended such an accident. As it was, there was only intermittent hemorrhage, corresponding to respiration. I was naturally afraid of the suction of air into the circulation, and I distinctly heard a slight sibilant suction with inspiration, and saw some bubbles of air mixed with the blood. Instantly I covered the opening with my finger, and soon was able to place a pair of hæmostatic forceps between the tear and the heart. With not a little difficulty I was able finally to surround the vein with a silk ligature. The vein was then tied also beyond the tear, and severed between the two ligatures.

The flaps were then made by two incisions commencing about three inches above the acromion, passing down one over the anterior and the other over the posterior border of the axilla, to a point two inches in front of the lower angle of the scapula. The anterior incision crossed that over the clavicle nearly at a right angle. All the anterior tissues were first cut through, and the nerves divided, when the arm and scapula immediately fell away from the trunk.

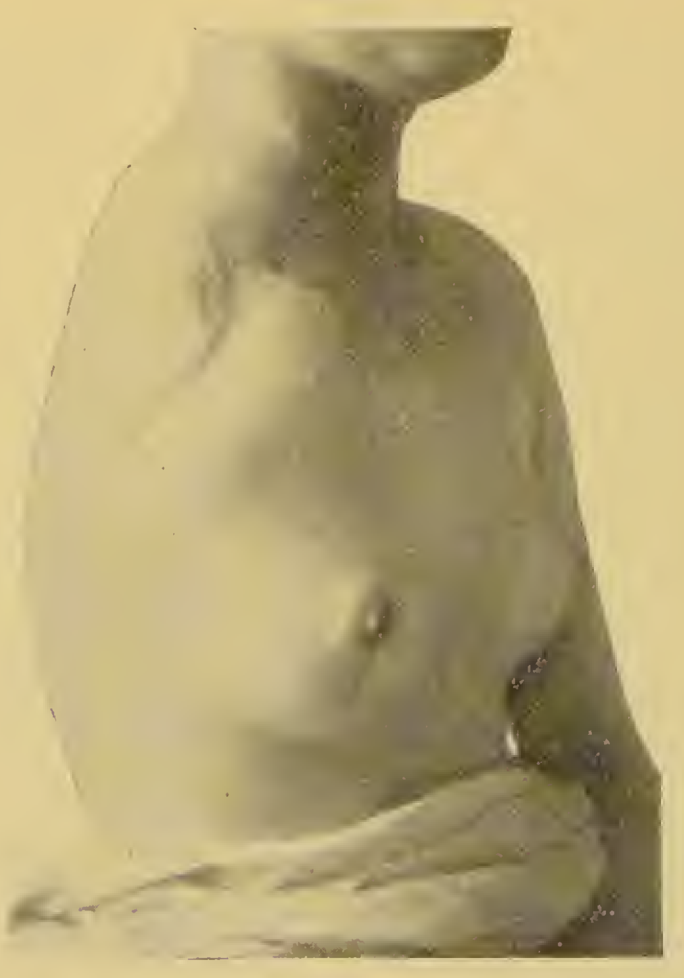
The posterior flap was then rapidly dissected from the scapula, when the operation was easily completed by severing the muscular attachments of the latter bone. No large vessels were cut, but nearly thirty ligatures had to be placed on small vessels, including a few small veins which bled persistently. The flaps came together easily, without trimming, a drainage-tube was inserted at the lower angle, and an abundant sterilized dressing applied.

During the operation she only required one dose of gr. $\frac{1}{20}$ of strychnine, and although the operation lasted nearly an hour and a half (most of which time was required in securing the vessels), she was put to bed in very good condition, with only moderate shock.

December 15*th*. On the second day after the operation the drainage-tube was removed from the upper end of the wound, and on the third from the lower end, and a little iodoform gauze was inserted in its place. Half of the stitches were removed on the fifth day, and the remainder on the seventh, and she was out of bed on the eighth day. Her temperature only once, on the evening of the operation, reached 101°, and fell to the normal at the end of forty-eight hours. Very slight suppuration occurred at the lower end of the wound, but the whole wound was closed at the end of ten days. On December 11th, three weeks after the operation, a ligature came away from the site in the subclavian vessels. Its discharge was preceded for two days by a little redness, but no rise of temperature. My impression is that the escape of the ligature was due to necrosis, probably at the end of the vein. Had the ligature been infected it would have created more trouble, of course, and at a much earlier period. I had myself boiled the silk for an hour before the operation.

The patient was sent home to-day (twenty-fifth day) with the secondary opening over the subclavian vein almost closed, the rest of the wound entirely well. The photograph (Fig. 19) shows the result. The scar has faded to a marked extent.

FIG. 19.



Dr. Coplin reports that the growth is a myeloid sarcoma.

May 10, 1894. The patient remains in good health, and is attending college.

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